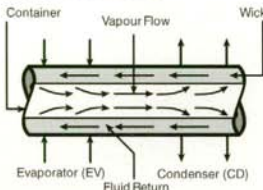


General Description

The **ISOPIPE** consists of an evacuated and sealed boiling-condensing system with capillary return (via an absorbent 'wick' structure) of the condensed working fluid from the condenser to the evaporator.

By utilizing the latent heat of vapourisation of the circulating working fluid, large quantities of thermal energy may be transferred considerable distances through relatively small diameters in an entirely passive manner. (Fig.1).

Fig.1 - Section of ISOPIPE



Cooling Cores

The conventional method of cooling cores is illustrated in Fig.2 and that using the **ISOPIPE** in Fig.3. Water circulation through cores means expensive tool costs and when in operation unforeseen troubles frequently occur. Any contaminants in the system soon begin to block passageways, particularly at bends, and scale deposition may even begin at low temperatures. When nucleate boiling within a core occurs it is usually at the tip and scale deposition is rapid, both restricting the water flow and reducing the cooling effect dramatically at the most vital region.

Chilled water may be used to overcome these problems but at this stage the remedy may be too late and the by-product, usually, is a tool that sweats.

Fig.2 - Water-Cooling Method

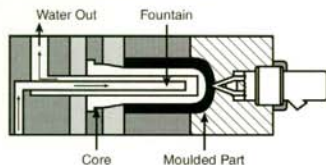
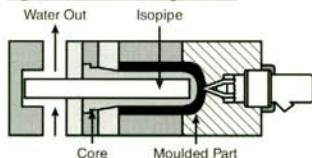


Fig.3 - ISOPIPE Cooling Method



Apart from these problems, and including cracked cores which will allow water seepage into the cavity, the downtime and maintenance costs often produce an average cycle time, and consequent expense, exceeding the anticipated production costs.

These problems can be eliminated by using the **ISOPIPE** to act as a thermal transformer, extracting high energy levels from the core and passively conducting the heat into the body of the tool, where adequate water cooling is readily available. Because no water enters the core no clogging or scaling can occur, and even if the core is cracked no water can leak into the cavity. The necessity of chilled water is eliminated because of the high heat absorption and rejection rate of the **ISOPIPE**. Indeed, in some applications this heat transfer system will work better with unchilled water because the **ISOPIPE** power handling increases with temperature. Consequently overcooling of some parts of the core, if chilled water is used, is eliminated and a product with much reduced stress and shrinkage marks may be produced.

Thus the high heat fluxes encountered in the metal diecasting and plastic moulding industries may be readily absorbed and transported - even over considerable distances. Hot spots and associated temperature gradients may be similarly removed.

The **ISOPIPE** can replace mould fountains, cascades etc. It simplifies tool construction. No wear, no blocking of the waterways due to excessive scaling, are some of the advantages it has over conventional water cooling systems.

Diameter

Generally, use the largest diameter **ISOPIPE** possible within a given core. This must be compatible with maintaining the necessary mechanical strength of that core to withstand material injection pressures and subsequent part extraction.

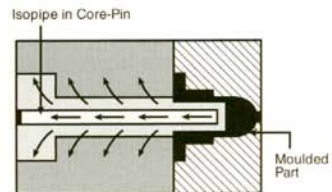
Length

This is obviously a function of the design of the die and the waterways within it. It is, however, worthwhile noting that whereas, conventionally, the cooling water may have been cascaded through the core, it is feasible to transfer heat from the hot core-pin to the back of the bolster (Fig.4), and then to rely on the mechanical contact between the **ISOPIPE** and bolster. (This utilises the large thermal mass of the latter to disperse the heat).

This is a considerable advantage as it may allow a simplification of the design of the die with the possible elimination of various waterways.

This practice is very effective for small mouldings where previously no cooling has been installed in the core-pin. A small diameter **ISOPIPE** fitted into the core-pin will dramatically decrease the cycle time, the heat from the small moulding being transferred to the bolster set.

Fig.4 - Core-Pin Without Water Cooling



Cores Converted into Isopipes

A core may be turned directly into an **ISOPIPE** by capping, or attaching an extension to the water cooled end.

This process is usually undertaken if the diameter is small, or the cross section of the core is not circular. By using the hole in the core pin as the inner surface of the **ISOPIPE** a larger vapour space is provided, together with a slightly larger wicked area. This implies that a higher performance can be achieved.

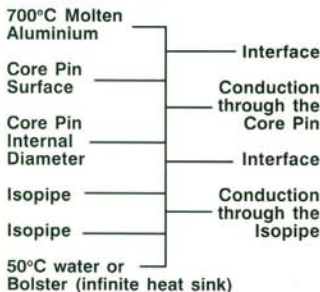
Inevitably, in very small core pins this method of cooling may be the only practical method.

Temperature

At first sight, the choice of temperature range of the **ISOPIPE** may appear most difficult, with the extremes of temperature of molten Aluminium (greater than 660°C) and chilled water (less than 10°C) being encountered.

Careful analysis of the problem will, however, radically reduce the probable operating temperature range of the **ISOPIPE** to reasonable limits - we consider the operating temperature as the temperature of the vapour within the **ISOPIPE**, and *not* that of either the heat source (molten Aluminium) or the heat sink (chilled water).

As a simplified guide, consider the following thermal path:

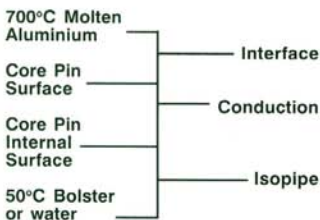


Within this total thermal path, the effective thermal conductivity of the ISOPIPE (remembering its isothermal nature) is so great (1,000 x that of Copper, 8,000 x that of Steel) that it contributes virtually nothing to the temperature gradients of the system and it may therefore be ignored.

We may also neglect the interfaces immediately adjacent to each end of the ISOPIPE as, in the case of a bolster cooled system, these will usually be almost identical (assuming similar evaporator and condenser lengths and fits) and will thus yield equal temperature gradients. No matter how large those gradients may be, being at opposite ends of the ISOPIPE they will not affect its operating temperature.

Similar considerations apply to water cooled ISOPIPES, as even though the cooled (condenser) length is often very much less than the heated (evaporator) length, (typically by a factor of 5), the surface heat transfer coefficient between the cooling water and ISOPIPE surface is some 5-10x greater than the thermal conductivity through the normal mechanical interface encountered.

Our rather long thermal path, may therefore, be approximated as follows:



The difficulty now arises in quantifying the above thermal path which because individual variations in core pin size, geometry, die design, injection temperature, injection pressure and cycle time etc., requires the most complex calculations for each particular die.

A simplified generalised indication of the probable ISOPIPE temperature can be obtained, however, merely by considering a typical cycle of the diecast and allowing that the molten Aluminium/core pin will act as a 'slugged' response system to 'step' changes in surface temperature.

Consider a cycle as follows:

- Time=0 Inject, Aluminium at 700°C.
- Time 0-½ 't' Aluminium cools to 200°C.
- Time ½ 't'-'t' Die is opened, cast extracted, Die is closed ready for fresh injection - Core has cooled to 100°C.

Because of the 'slugged' response, a time weighted average of the temperatures will produce an approximation to the core pin temperature.

$$\text{viz: } 2/3 \frac{(700+200)}{(2)} + 1/3 \frac{(200+100)}{(2)} = 350^{\circ}\text{C.}$$

(NOTE: This gives an indication of the temperature of the internal diameter of the core pin as its surface temperature will vary over quite wide limits).

Furthermore, the ISOPIPE may be considered to run at an average of this temperature and the bolster temperature.

$$\text{i.e. } \frac{350+50}{2} = 200^{\circ}\text{C.}$$

This estimation is fully borne out ($\pm 50^{\circ}\text{C}$) by both a more rigorous mathematical analysis and by the many tests both we and users have performed. We are now in a position to determine the correct temperature range of operation for the ISOPIPE, viz 150°C-250°C.

Although temperatures of 660°C+ exist within the die (i.e. the molten Aluminium), these have no direct relevance to the operating temperature of the ISOPIPE as already demonstrated.

Installation

The ISOPIPE is inserted into the hole in the core which would normally have been used for the water fountain or alternative water cooling system. The ISOPIPE should be inserted as near to the tip of the core as possible, bearing in mind no rusting or corrosion can now occur at this point.

The cooled length of the ISOPIPE should ideally be approximately 50% of the heated length, but will vary from application to application. Operation of the device is usually in the horizontal position but will also work very effectively when vertical with the cooled end uppermost. Shorter ISOPIPES up to 100mm long will also operate inverted.

The hole diameter in the core should give a radial gap between the ISOPIPE of 0.05/0.13mm (0.002/5"); a good fit should be avoided as this will not result in a good thermal joint.

A small quantity of THERMOFLEX* (thermally conductive grease) or THERMOBOND* (epoxy resin) should be placed on the tip of the ISOPIPE or at the bottom of the drilled hole. The quantity required is surprisingly small, but if the hole is not flat-bottomed the volume of the void must be added. Typically, for a 6mm diameter ISOPIPE inserted to a depth of 75mm the quantity of THERMOFLEX will be 0.15cm³.

The ISOPIPE is now inserted into the core very easily until compression forces the grease back up the air gap, thus making a perfect thermal joint. The pressure applied to achieve this action should not exceed 2.5Kg and the process will be completed within minutes. Make sure the ISOPIPE is installed to its calculated depth and then wipe off any excess grease which has appeared where the ISOPIPE enters the core.

It will be found that due to hydraulic action the ISOPIPE is more difficult to remove than it was to install.

*THERMOFLEX and THERMOBOND have a thermal conduction similar to Steel. A larger gap than recommended between the core-pin and ISOPIPE will not be unduly detrimental to the performance provided that the gap is filled with the thermally conductive compound.